A PRACTICAL METHOD FOR TEACHING MINE WORKERS AND OFFICIALS USE OF GAS-DETECTING EQUIPMENT

BY D. S. KINGERY AND F. D. BAKER

* * * * * * * * * **Information Circular 7639**

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INTRODUCTION

Owing to changes in State mining laws, the Maryland Bureau of Mines requires all mine foremen to have a thorough, practical knowledge of mine gases and the limitations and use of recognized gas-detecting devices. This requirement involves immediate training of second-grade mine foremen and aspirants to qualify them for certification under the new law. Cooperation of the Federal Bureau of Mines was requested, and a plan for training was discussed and adopted.

The methods used in Maryland aroused unusual interest by participating individuals, and the final results were very satisfactory. Consequently, it is thought that this plan will be of interest and assistance to other organizations faced with the need for such training.

This publication contains observations made during the 1949, 1950, and 1951 training periods in Maryland and includes suggestions to expedite and improve the quality of training. The training was conducted on a high plane to develop individual experience and self-assurance. It was complete with lectures, demonstrations, and practical work and was concluded by an examination showing the record of each trainee's progress. Training similar to this can be initiated easily by mining organizations, State mining departments, individual mines, and vocational-training schools. The results will be beneficial to the mining industry, by providing better trained and more efficient personnel, thereby reducing potential hazards, and improving efficiency.

Coal mining in many areas of the United States has reached an advanced stage that requires extensive underground workings; also, several of the shallow more-accessible coal beds are becoming depleted, which will require mining of deeper coal beds in coming years. Potentially, both these developments increase the hazard of methane liberation, conceivably in regions that have previously been considered nongassy. The increased mechanization program of the coal industry, with the resultant speed of advance and concentration of working areas, also has increased the hazards of methane liberations and complicated the problems of mine ventilation.

Modern mining calls for a high degree of specialized and coordinated work; it also requires that personnel working at the faces in gassy mines understand the principles of accurate detection of gas. The problem confronting some State mining departments and vocational and company-sponsored training schools, as well as many workers in nongassy and potentially gassy mines is to familiarize workers with the use of recognized gas-detecting devices and with the limitations of such devices.

This circular does not imply that it is possible to simulate actual mine conditions in a laboratory or that individuals trained in a laboratory will immediately have full knowledge concerning the application of gas-testing equipment to the varying conditions generally encountered underground. The trainee will, however, develop a certain ability for gas detection, a knowledge of gas-detecting devices, and an appreciation of potential hazards, which, when combined with actual underground experience, should make him a safer and more responsible workman.

ACKNOWLEDGMENT

The authors are grateful for the assistance and information furnished by officials of the Maryland Bureau of Mines and for the splendid cooperation of the miners who attended the classes.

TRAINING AIDS UTILIZED

Building or Training Room. - This should be large enough to accommodate the proposed number of trainees, have black-out facilities, and be ventilated. Throughout the Maryland training, the rooms of a State college and two high-school buildings were used as training sites.

Gas-Detecting Equipment. - Equipment should include enough permissible flame safety lamps for individual training; electrical methane detectors for demonstration, practice, and checking purposes; and carbon monoxide and hydrogen sulfide detectors for group-demonstration and individual practice. (*See* figs. 1, 2, 3, 4, 5, 6, and 7.)

Lamp-Testing Boxes. - One lamp-testing box should be available for every three to four trainees. Boxes should be of adequate size and constructed to retain air-gas mixtures for a reasonable period. (*See* fig. 8.)

Methane-Testing Gallery. - The gallery should be large enough to accommodate two men. It also should be equipped with an air lock and be capable of retaining air-gas mixtures. A small room could be substituted for the gallery, and air-lock doors could be set up for the room. (*See* fig. 9.)

Source of Gas. - Training will require relatively large volumes of methane; if possible, utility-delivered natural gas should be used. Bottled methane is satisfactory if local methane is not available. For demonstrations or tests of carbon monoxide or carbon dioxide, bottled gas or improvised sources are satisfactory.

Student Guide Gas-Detection Charts. - There should be enough illustrated methane-detection charts for study and reference; also, handbooks, such as the Bureau of Mines Miner's Circular 33, Mine Gases and Methods for Detecting Them. At least one chart is recommended for each lamp-testing box. (*See* figs. 10, 11, and 12.)

Miscellaneous. - Accessories for service and repair of flame safety lamps should be on hand, such as spare parts, naphtha, cleaning brushes, and magnets.

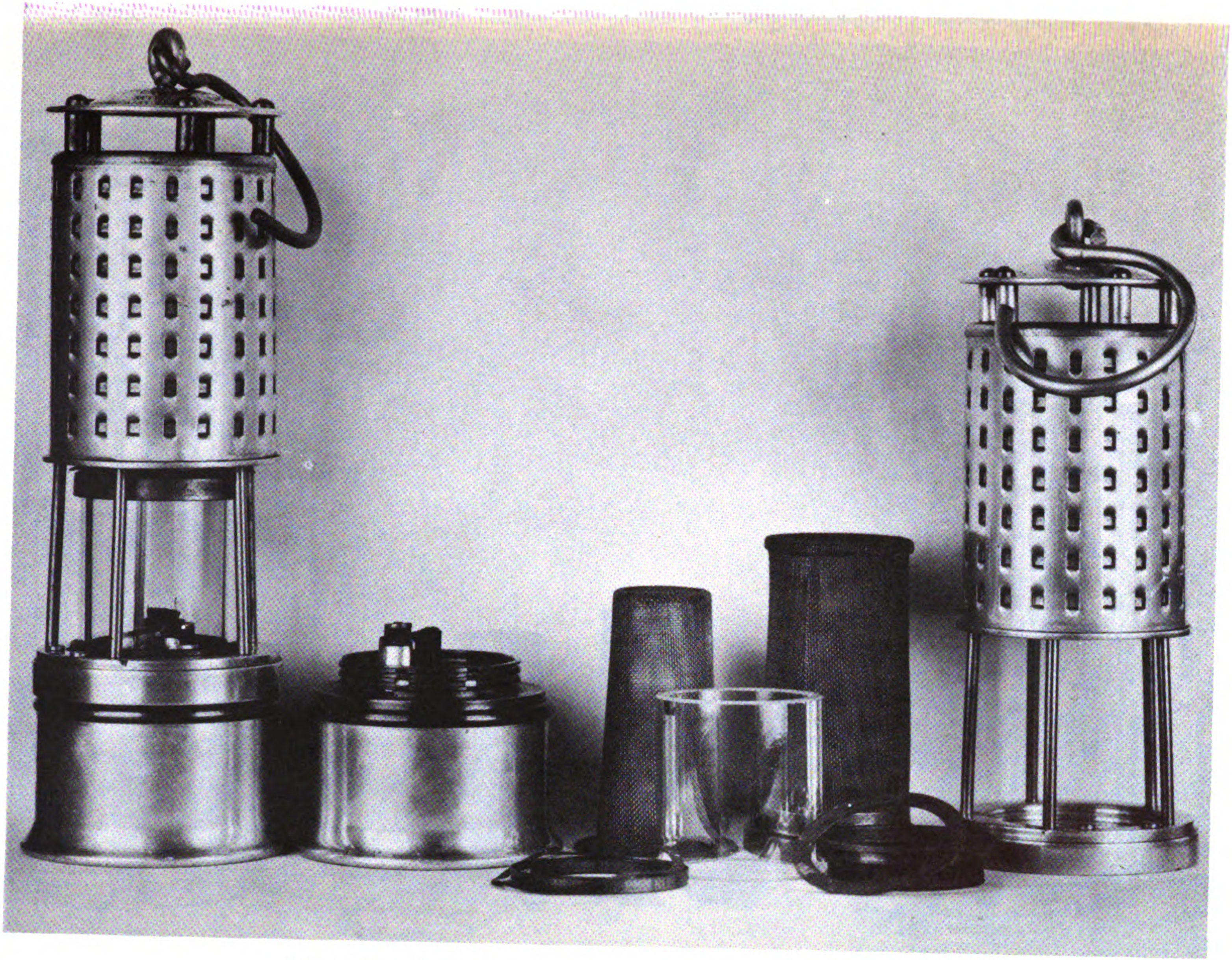


Figure 1. - Assembly and disassembly of flame safety lamps.

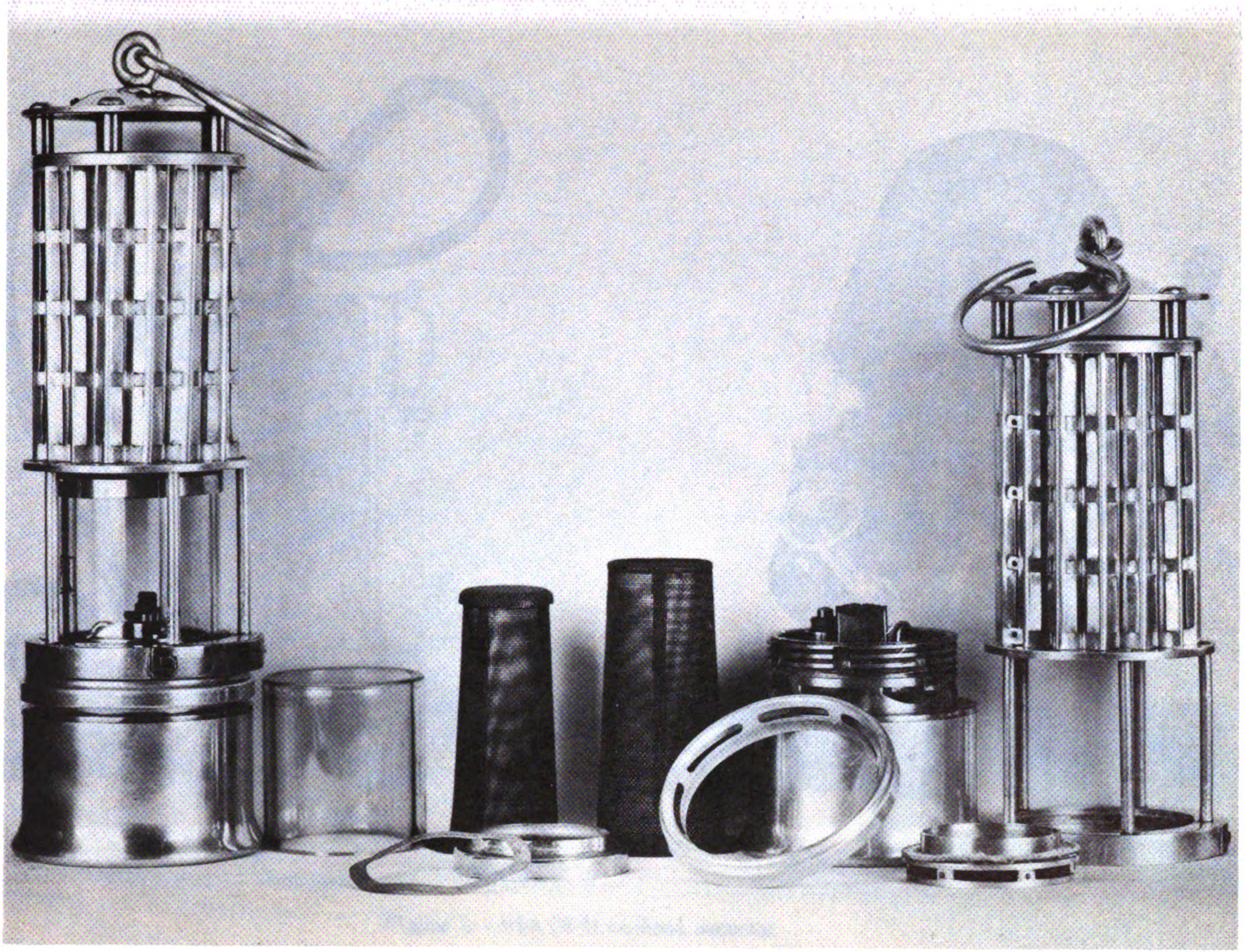


Figure 2. - Assembly and disassembly of flame safety lamps.

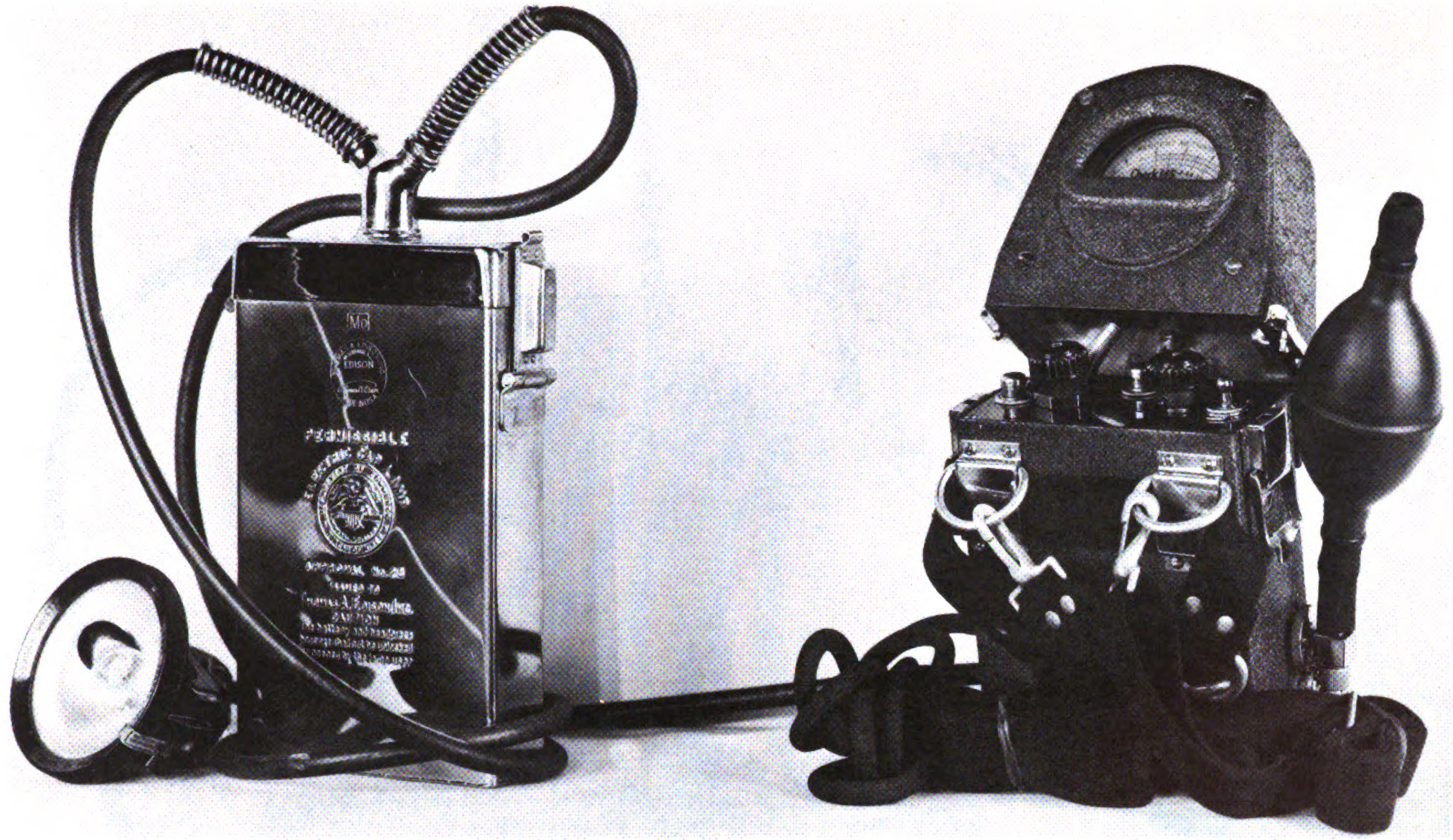


Figure 3. - MSA (W-8) methane detector.

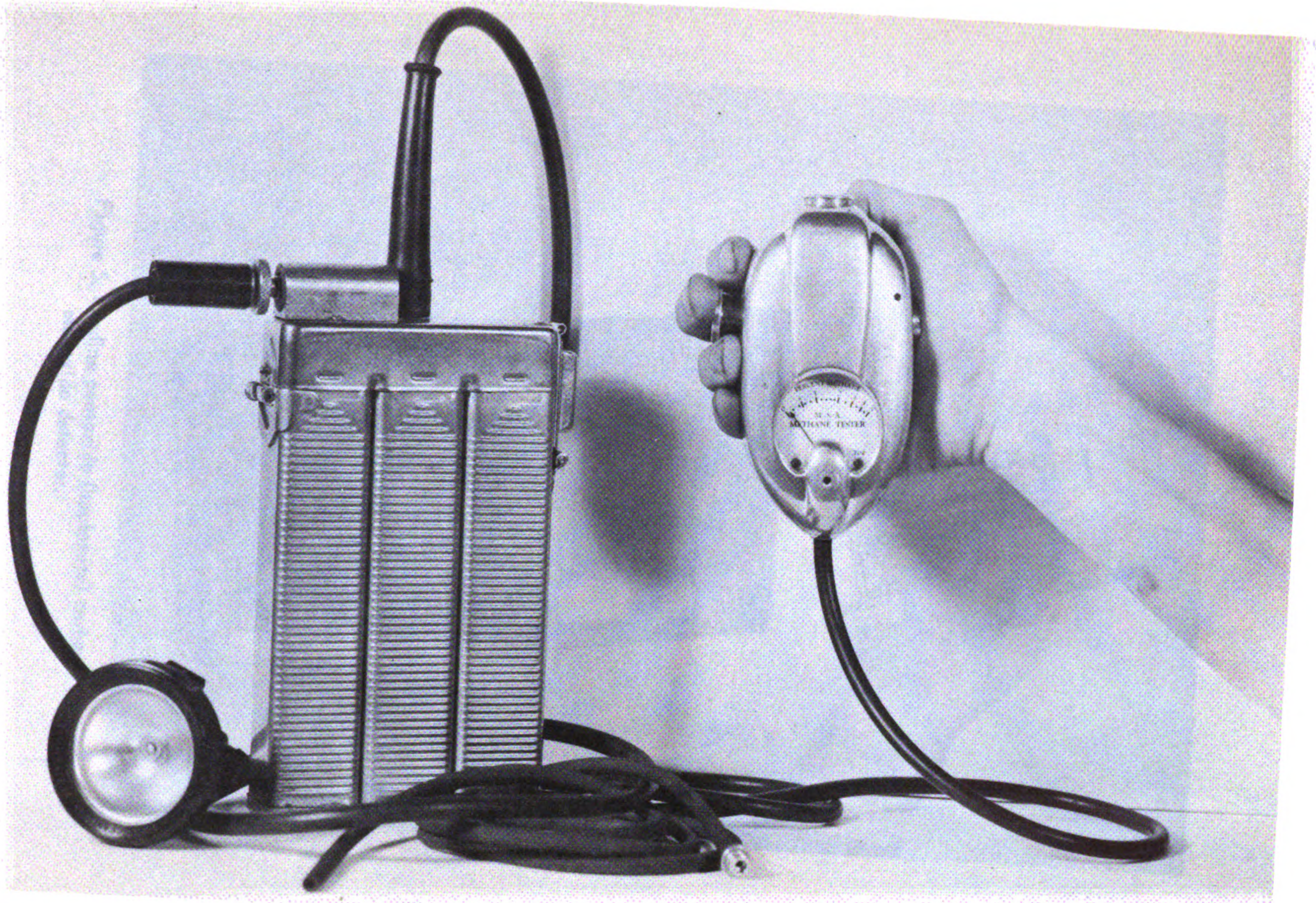


Figure 4. - MSA (E-2) methane detector.

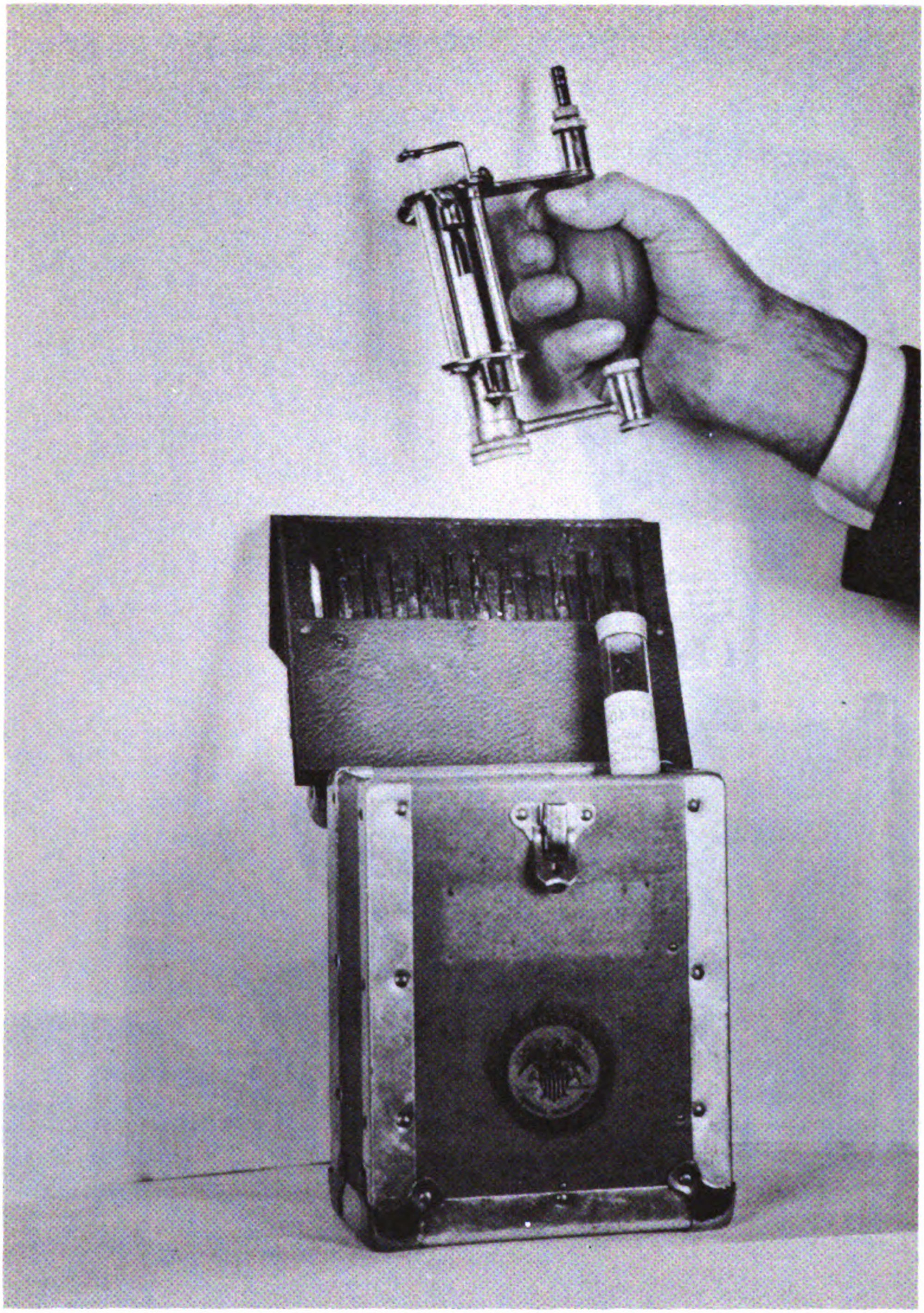


Figure 5. - Iodine pentoxide (hoolamite) carbon monoxide detector.

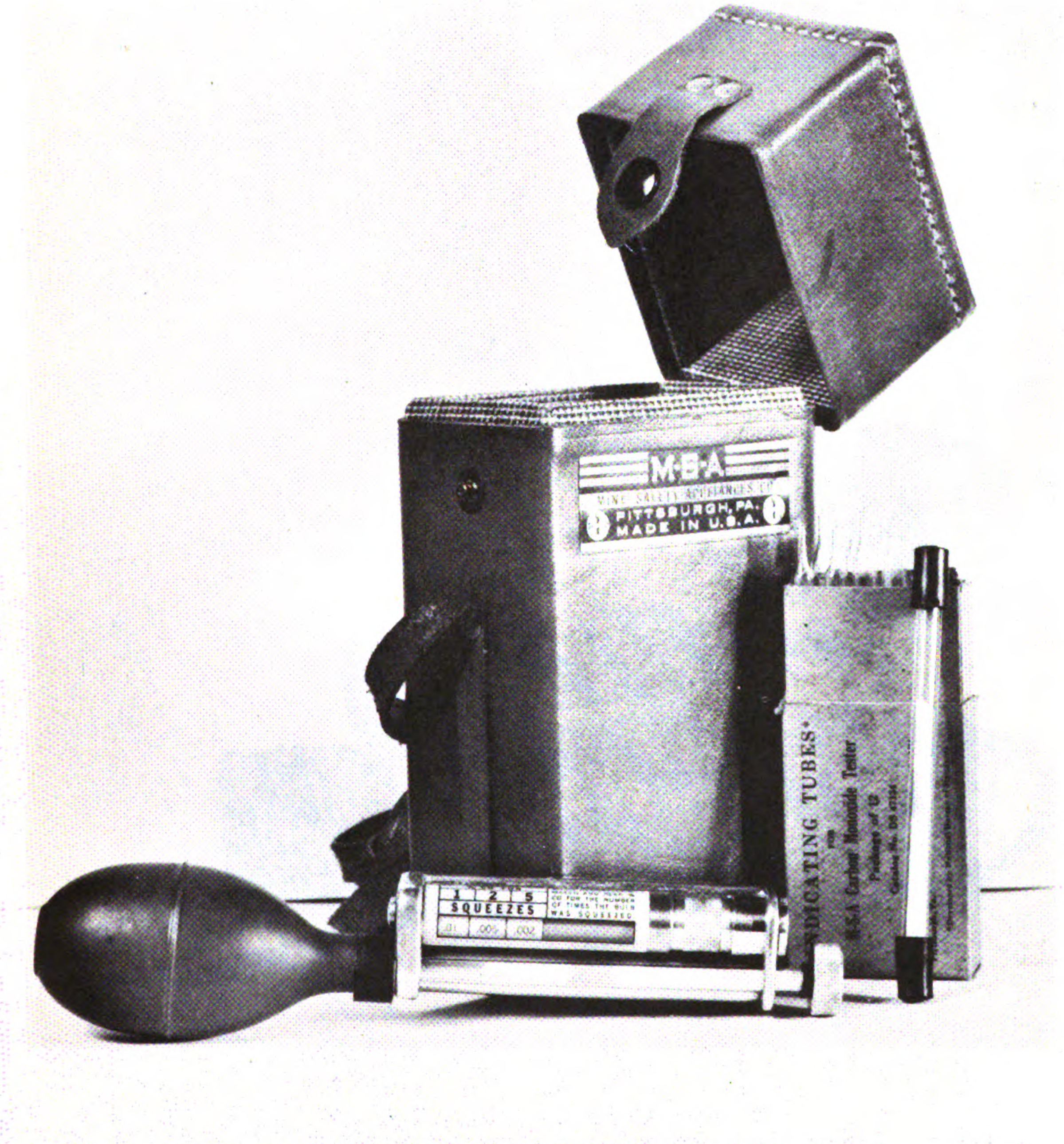


Figure 6. - MSA colorimetric carbon monoxide detector.

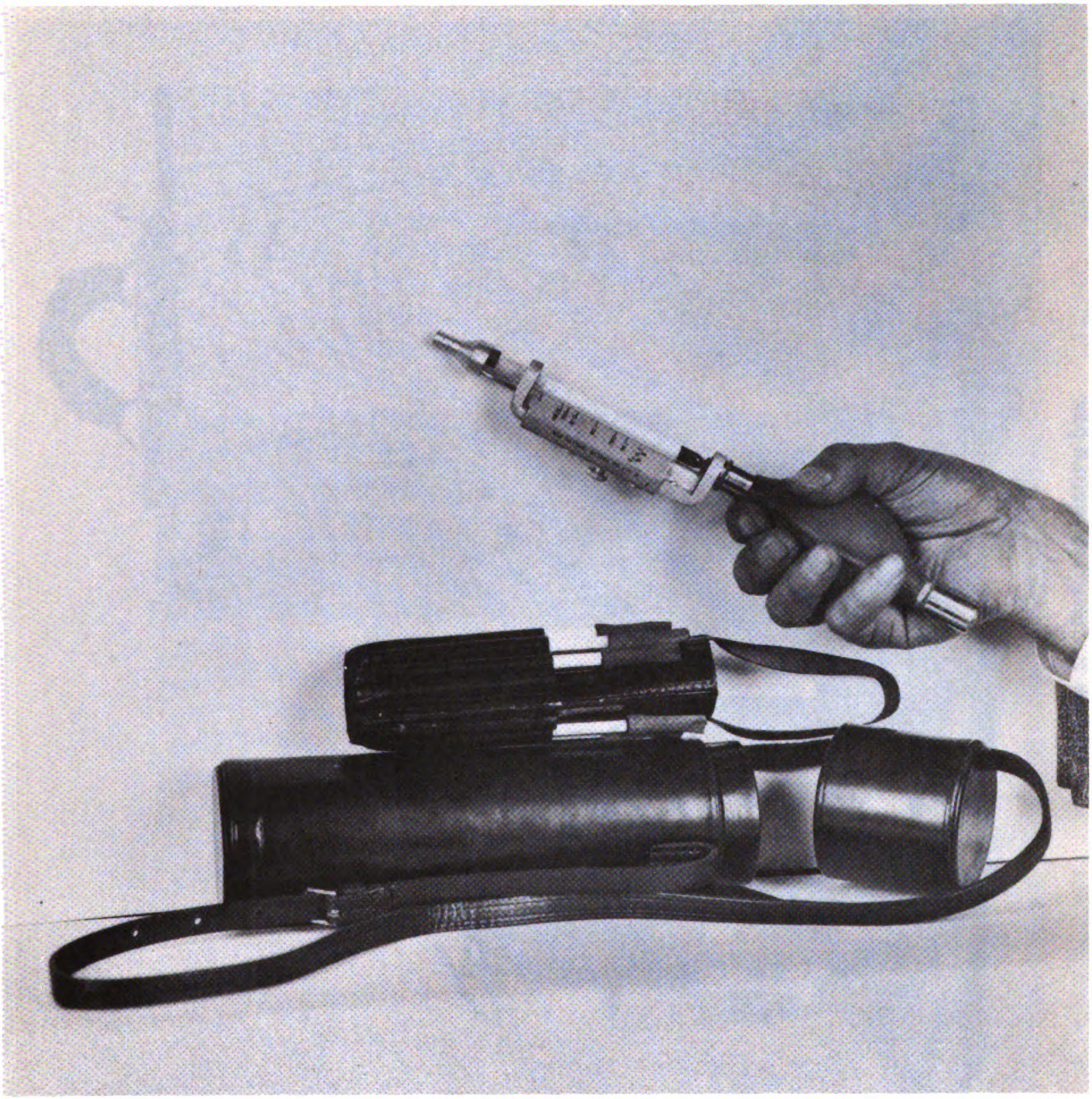


Figure 7. - Hydrogen sulphide detector.

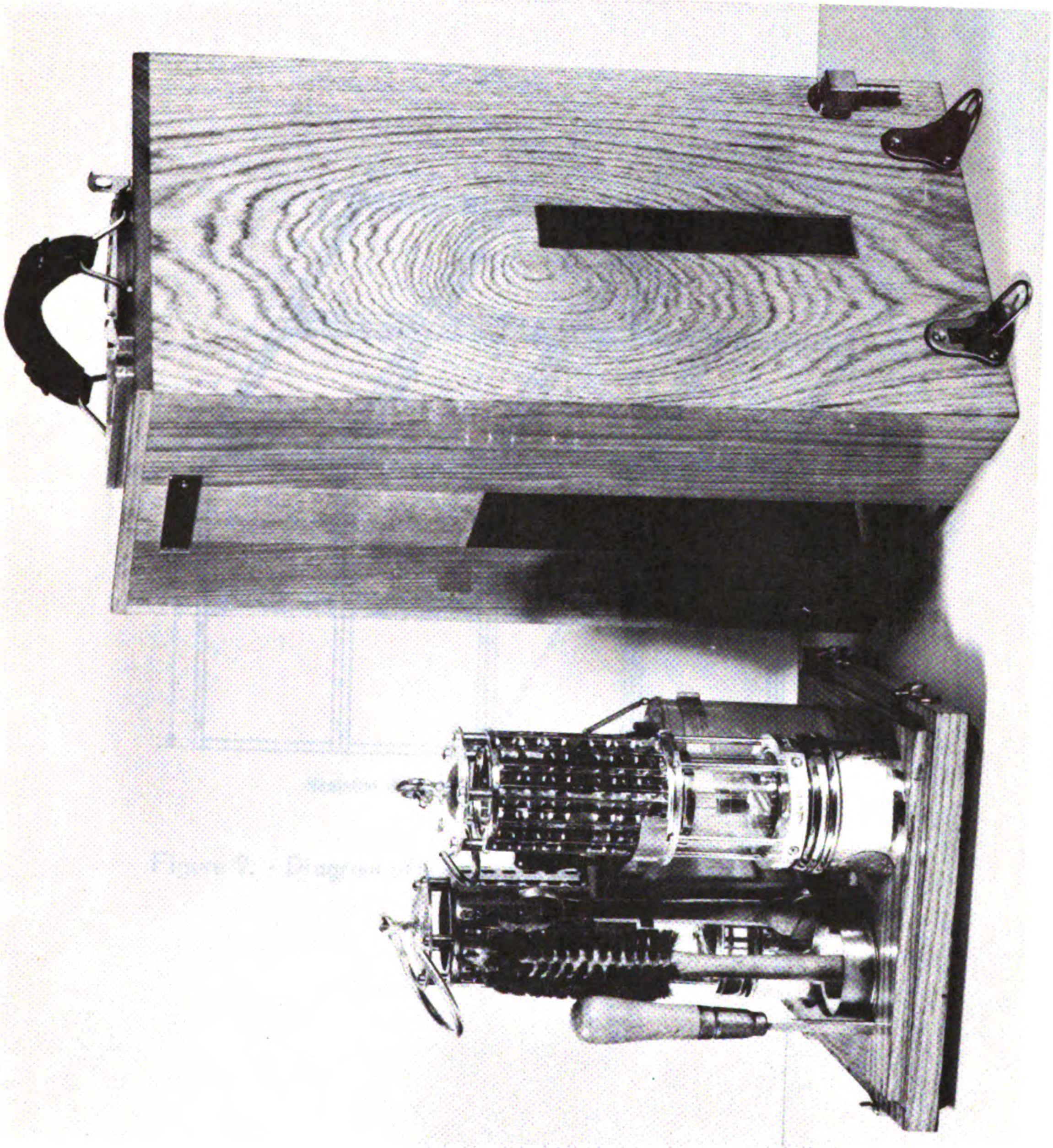
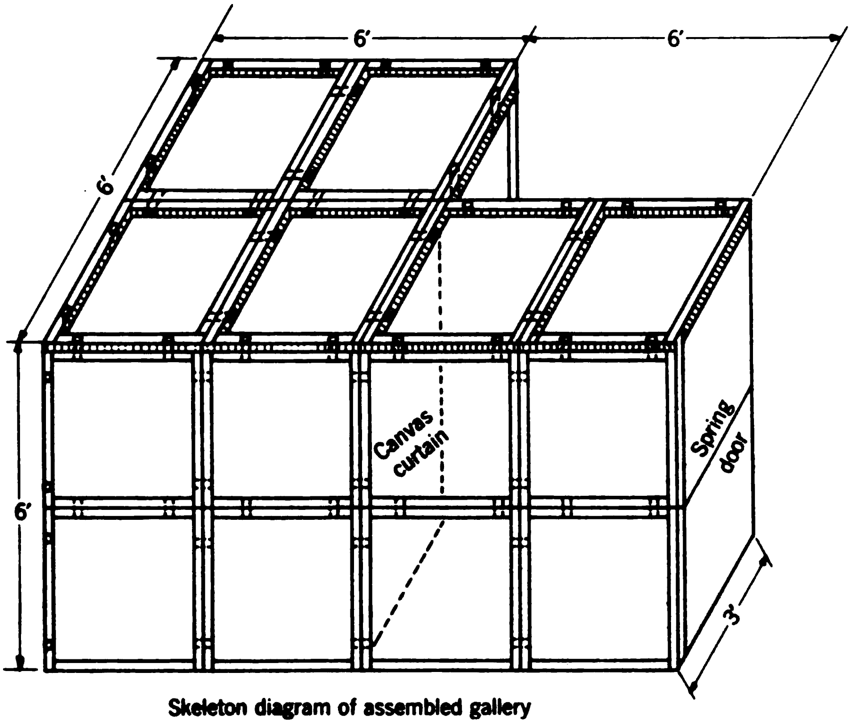
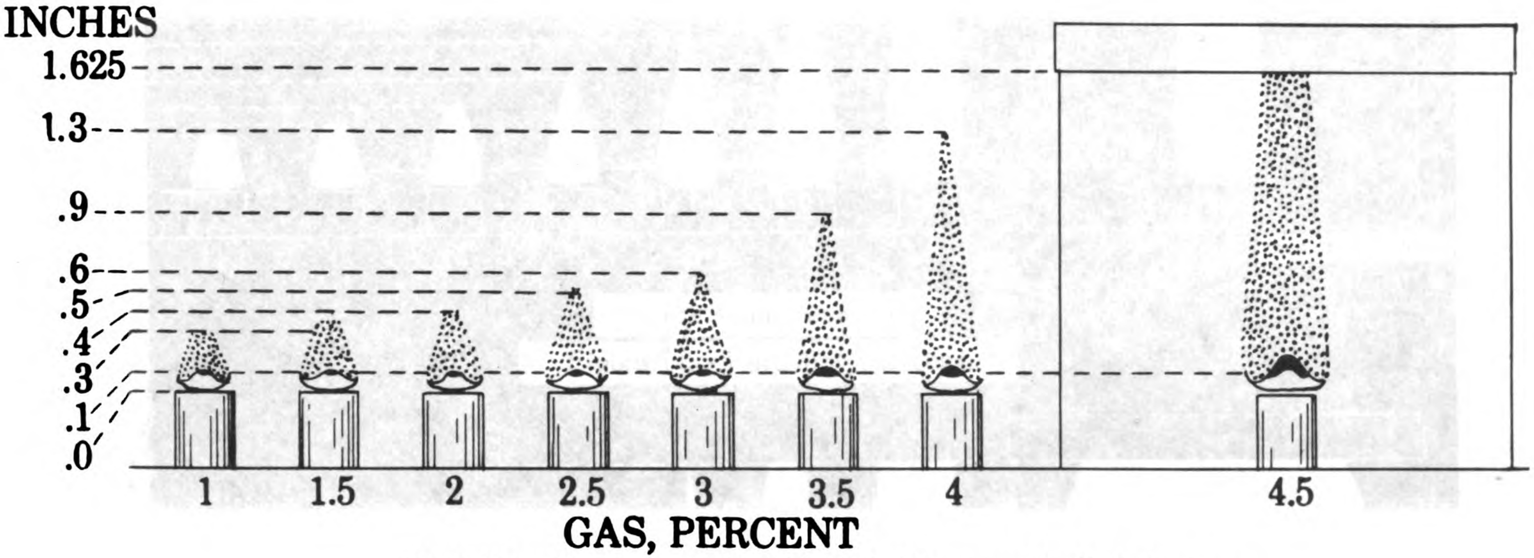


Figure 8. - Methane testing box.



Skeleton diagram of assembled gallery

Figure 9. - Diagram of assembled methane testing gallery.



Height of gas caps with Wolf round-wick lamp
Testing flame 0.1 inch high

Figure 10. - Height of gas caps.

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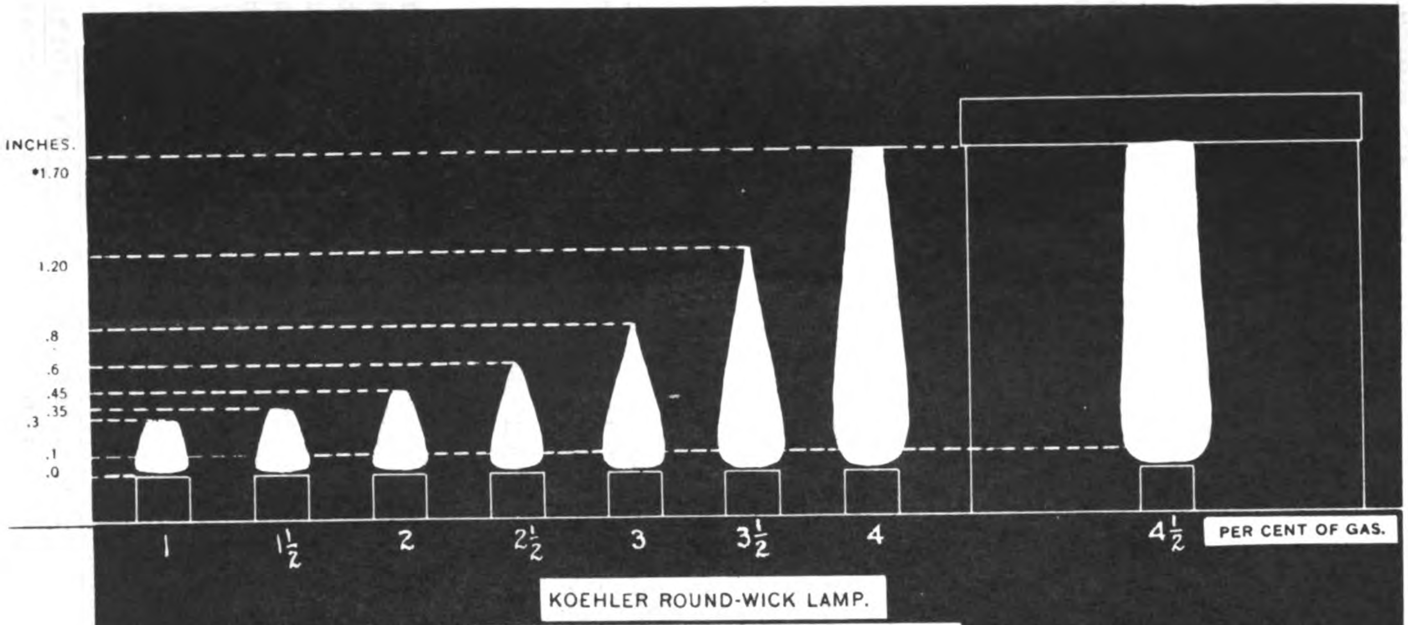

Figure 11. - Height of gas caps.

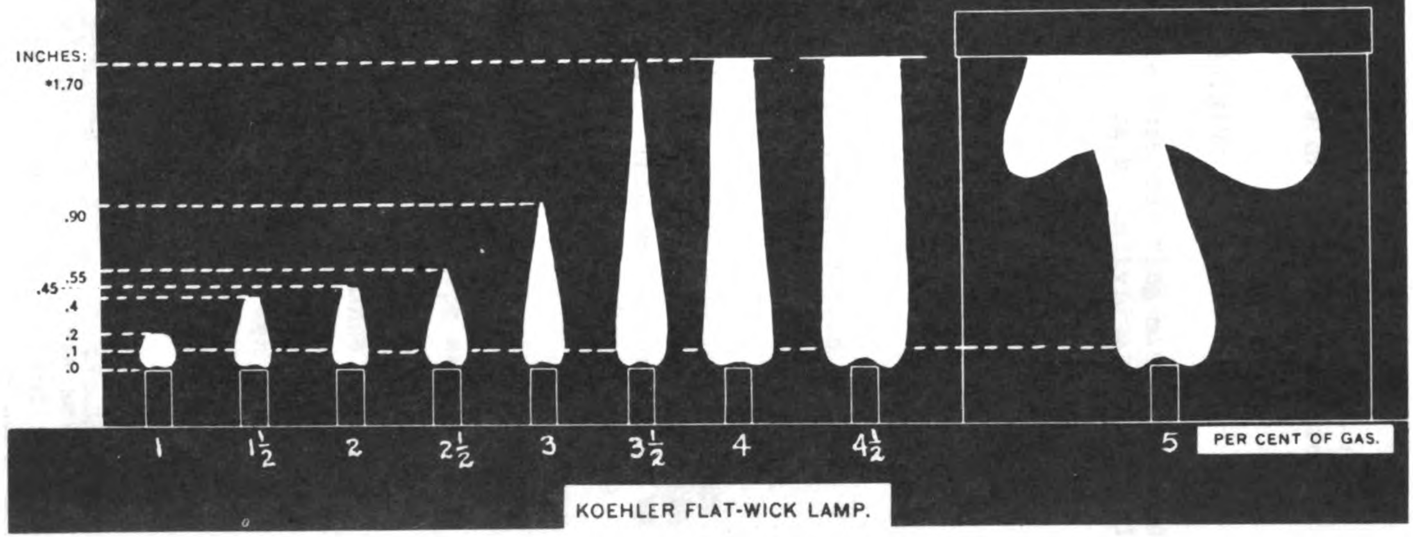

Figure 12. - Height of gas caps.

Cap-lamp batteries and headpieces with which to operate electrical methane detectors are necessary.

Also needed is demonstration equipment, such as a blackboard and an arcs and sparks gallery with attachments. Motion pictures of gas-detection procedures and methods should be used if available.

SEQUENCE AND METHOD OF TRAINING

Lecture and Demonstration. - A preliminary lecture covering mine gases and their detection was given, after which, practical work by individuals was initiated. This lecture consisted of the following:

a. Names of gases.
b. Composition and abundance.
c. Weight and solubility.
d. Origin (where found).
e. Effect on life.
f. Combustion (explosive range).
g. Detection methods (history, explanation, and demonstration of gas-detecting devices, functional operation, and limitations).
h. Protective devices.

Practical Work Exercises. - The practice-training period was long enough to permit all trainees to develop a working knowledge of gas-testing equipment and a self-assured ability to make actual gas tests. This was accomplished by scheduling the time to permit the use of facilities without overcrowding and to permit maximum individual instruction and practice.

PROCEDURE AND SCOPE OF TRAINING

Permissible Flame Safety Lamps. - The Wolf- and Koehler-type safety lamps were disassembled and assembled. The instructor named and explained the purpose of each part, pointed out the difference in construction between lamps, and explained and demonstrated the importance of proper maintenance and the hazards of worn or dirty parts. The proper method of carrying and handling was demonstrated. Questions were answered and repeat demonstrations given as required. The class was then divided into groups of about five men for practical training under the supervision of the instructors. Practice continued until each man became conversant with the assembly and principle of the flame safety lamp.

Electrical Methane Testers and Detectors and Carbon Monoxide and Hydrogen Sulfide Detectors. - The instructor demonstrated the electrical-type methane detectors, explaining the mechanics, operating procedure, purpose, and limitations. Enough time was devoted to individual practice to assure that each person understood the operation and use of this equipment. Other gas-detecting equipment, such as carbon monoxide and hydrogen sulfide detectors, were explained and demonstrated; time then was devoted to individual practice permitting the student to become familiar with the purpose of the devices and the general operating principles.

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Gas Detection in Lamp-Testing Box or Gallery. - The class was divided into groups of three or four men. Each group was provided with permissible flame safety lamps and assigned to a lamp-testing box. The instructors reviewed the fundamentals of gas detection and demonstrated to each group the use and principle of the walking and capping flames. Personnel also was instructed in operation of the testing boxes and warned of the potential hazards when using explosive mixtures for practice testing.

Following this preliminary demonstration, the students practiced gas detection within the lamp-testing boxes. The instructors checked their determinations by electrical methane detectors and by the methane-detection charts. This permitted the trainee to check his progress and develop self-confidence. After each student had advanced to the point of reasonable consistency, three of these small groups were merged into a large group for further training.

Advance training by groups was conducted by permitting some member of each group to prepare three or more of the lamp-testing boxes in the absence of the other men. The instructor then tested the skill of each man by his ability to detect the mixtures in these boxes. This type of supervised training was found to be more beneficial than permitting each person to prepare his own box and make general practice tests. This method eliminated preconceived opinions and the tendency to guess rather than actually see cold indications during practice testing. Each man's readings were checked with an electrical methane detector. Errors were pointed out, and suggestions were given as to how mistakes could be avoided.

Practice in detecting oxygen deficiency was begun after the class had developed a reasonable skill in gas testing and familiarity with the flame safety lamp. The oxygen from the gas-detecting box was depleted with an open flame, and explanations and further demonstrations were given. Then each student practiced and studied the effect of this phenomenon on his flame safety lamp.

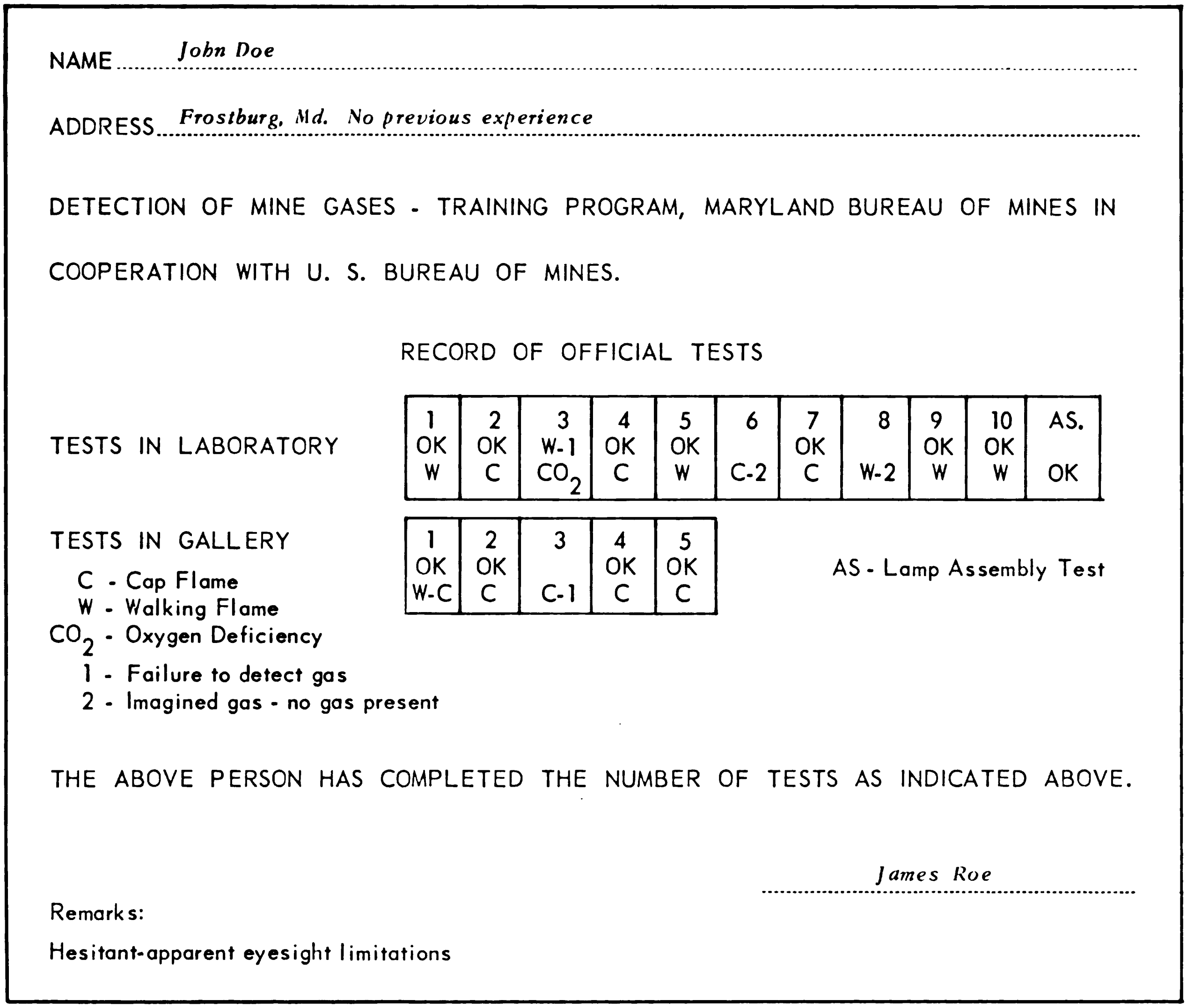
Throughout this practical training, the gallery (see fig. 9) was used in much the same manner as the lamp-testing boxes. Tests in the gallery constituted the nearest approach to mine conditions and were used to demonstrate the possibility of gas mixtures at varying levels, the limitation of the walking flame in a diffused gassy atmosphere, the advantage of the capping flame, and the effect of constant temperature on lamp performance.

EXAMINATION OF TRAINEES

As a climax to the training program, an examination was held to assure the men they had learned the lessons taught and to emphasize the importance of accuracy in using testing equipment when on the job.

Following are the standards used during the examination:

a. 1.5 percent methane was accepted as the lowest limit that could be detected consistently with a flame safety lamp.



NAME *John Doe*

ADDRESS *Frostburg, Md. No previous experience*

DETECTION OF MINE GASES - TRAINING PROGRAM, MARYLAND BUREAU OF MINES IN COOPERATION WITH U. S. BUREAU OF MINES.

RECORD OF OFFICIAL TESTS

TESTS IN LABORATORY

1	2	3	4	5	6	7	8	9	10	AS.
OK	OK	W-1	OK	OK		OK		OK	OK	
W	C	CO_2	C	W	C-2	C	W-2	W	W	OK

TESTS IN GALLERY

1	2	3	4	5
OK	OK		OK	OK
W-C	C	C-1	C	C

AS - Lamp Assembly Test

C - Cap Flame
W - Walking Flame
CO_2 - Oxygen Deficiency
1 - Failure to detect gas
2 - Imagined gas - no gas present

THE ABOVE PERSON HAS COMPLETED THE NUMBER OF TESTS AS INDICATED ABOVE.

James Roe

Remarks:

Hesitant-apparent eyesight limitations

Figure 13. - Flame safety-lamp gas chart.

b. To eliminate indecision and guesswork among trainees, any man who announced that he could detect unreasonably small percentages of methane was not given a passing mark in this particular test.

c. In all cases, an electrical methane detector was used to determine the quantity of methane actually present. After this reading was made, the instructor marked each man's examination record card accordingly.

The examination itself consisted of three parts: (1) Assembly of the flame safety lamp; (2) 10 tests in the lamp-testing box with a flame-safety lamp, including both tests for gas and oxygen deficiency; (3) 5 tests in the gas gallery, comprising 15 gas tests and tests of lamp assembly and proper naming of parts of the lamp.

Records of the separate tests showed the performance of the individual and were valuable for future reference in aiding the trainee to become more adept in detecting gases. (See fig. 13.)

RESULTS OF TRAINING

With few exceptions, the men taking this training had no previous experience in detecting mine gases. The actual time spent in practice training ranged from 4 to 20 hours, 10 hours probably was the average per man.

Following is a partial summary of the examination results:

Number of men taking examination	113
Number of men compiling a perfect score	6
Number of men failing 1 test	22
Number of men failing 2 tests	33
Number of men failing 3 tests	26
Number of men failing 4 tests	14

Total number of tests failed:

	Failure to detect gas	Imagined gas
In gallery	47	63
In lamp box	105	70
	152	133
Failure in lamp assembly	14	
Failure to detect oxygen deficiency	16	

Total tests taken	1,808
Total tests failed	315
Number of correct detections	1,493 or 82.6 percent

OBSERVATIONS AND CONCLUSIONS

The instruction outline for this type of training should be well planned. All training aids and necessary material should be collected before training.

The instructors should be the best available, and there should be enough instructors to provide ample individual attention.

The classes should be scheduled for the best interests of personnel and training to avoid confusion and permit the maximum use of facilities. Preliminary individual training is the critical stage, because the natural tendency of most men is to load the gas-testing boxes heavily with methane. This depreciates the training, tends to develop overconfidence in individual detecting ability, and introduces potential hazards. All training should be closely supervised and be conducted within the lower detection range, backed by tests with electrical methane detectors to give individual attention to retarded personnel.

Advance group training should follow preliminary training. This was found to be most successful type of training. Particular care should be taken during gallery instruction to approximate mine conditions and to point out the effects of these conditions on detecting devices.

The results of this training illustrate how far laboratory practice can advance the knowledge of inexperienced men. It is obvious that persons completing such training have gained valuable experience in a phase of coal mining that is most important, from both safety and operational standpoints.

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